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SUMMARY: HYDROGEOLOGICAL INVESTIGATION FOR A MUNICIPAL GROUNDWATER SUPPLY DANVILLE, ILLINOIS

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1993
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Morris W. Leighton, Chief

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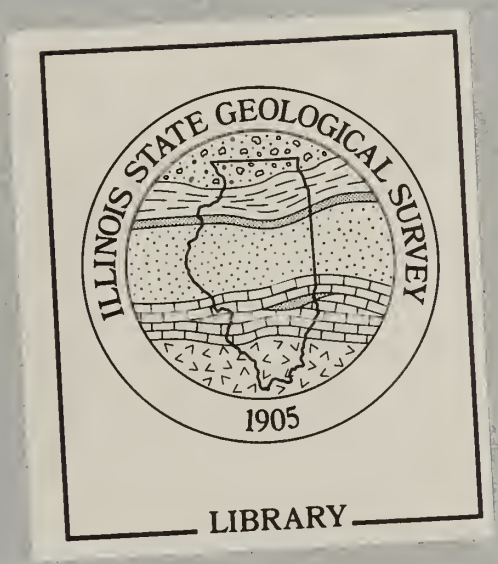

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Summary of Conclusions

Developing a supplemental groundwater supply for Danville in the area around Lake Vermilion may not be feasible for several reasons:

- The limited width of the sand and gravel aquifer in the Danville Bedrock Valley reduces the availability of groundwater.
- More high-capacity wells in the aquifer will decrease water levels in existing wells.
- Induced recharge from Lake Vermilion may increase the nitrate concentration in the groundwater, but not significantly increase available water supplies.

The best data available, including water well records and resistivity and seismic data, formed the basis for Kempton et al. (1981) indicating a high potential for the occurrence of thick, extensive deposits of sand and gravel in the confluence area of the Danville and Mahomet Bedrock Valleys in northern Vermilion County. An exploration program in an area from Lake Vermilion northward would better delineate groundwater availability. Test holes drilled to bedrock would ensure the assessment of the entire sequence and thickness of sand and gravel aquifers.

Introduction

Groundwater resources of the Danville area (figs. 1 and 2) were evaluated by the Illinois State Geological Survey (ISGS) and the Illinois State Water Survey (ISWS). The study was requested and partially supported by Inter-State Water Company. This summary briefly describes the background of the study, the geologic and hydrologic setting of the area, the distribution of the sand and gravel aquifers, and the conclusions of the study. The final report by Kempton et al. (in prep.) will fully present results of the study and recommendations for further exploration of the identified aquifers.

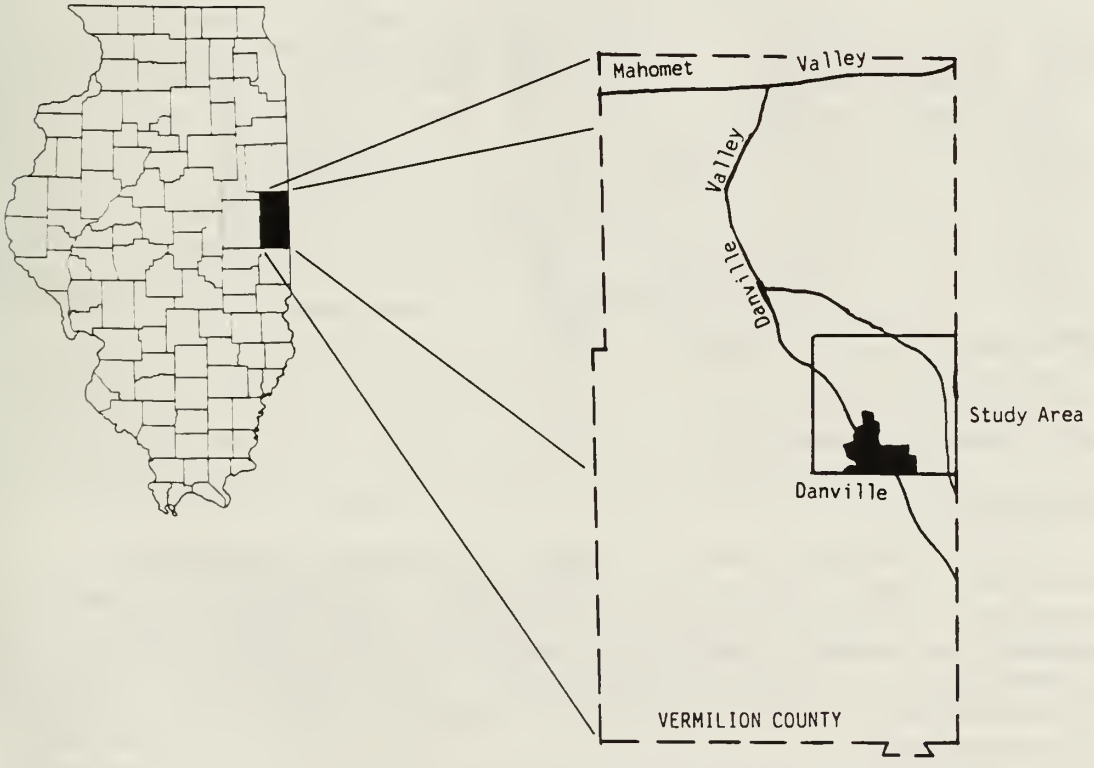


Figure 1 Location of study area in Vermilion County. The deepest parts (thalweg) of the Mahomet and Danville Bedrock Valleys are shown in relation to the study area (from Kempton et al. 1991).

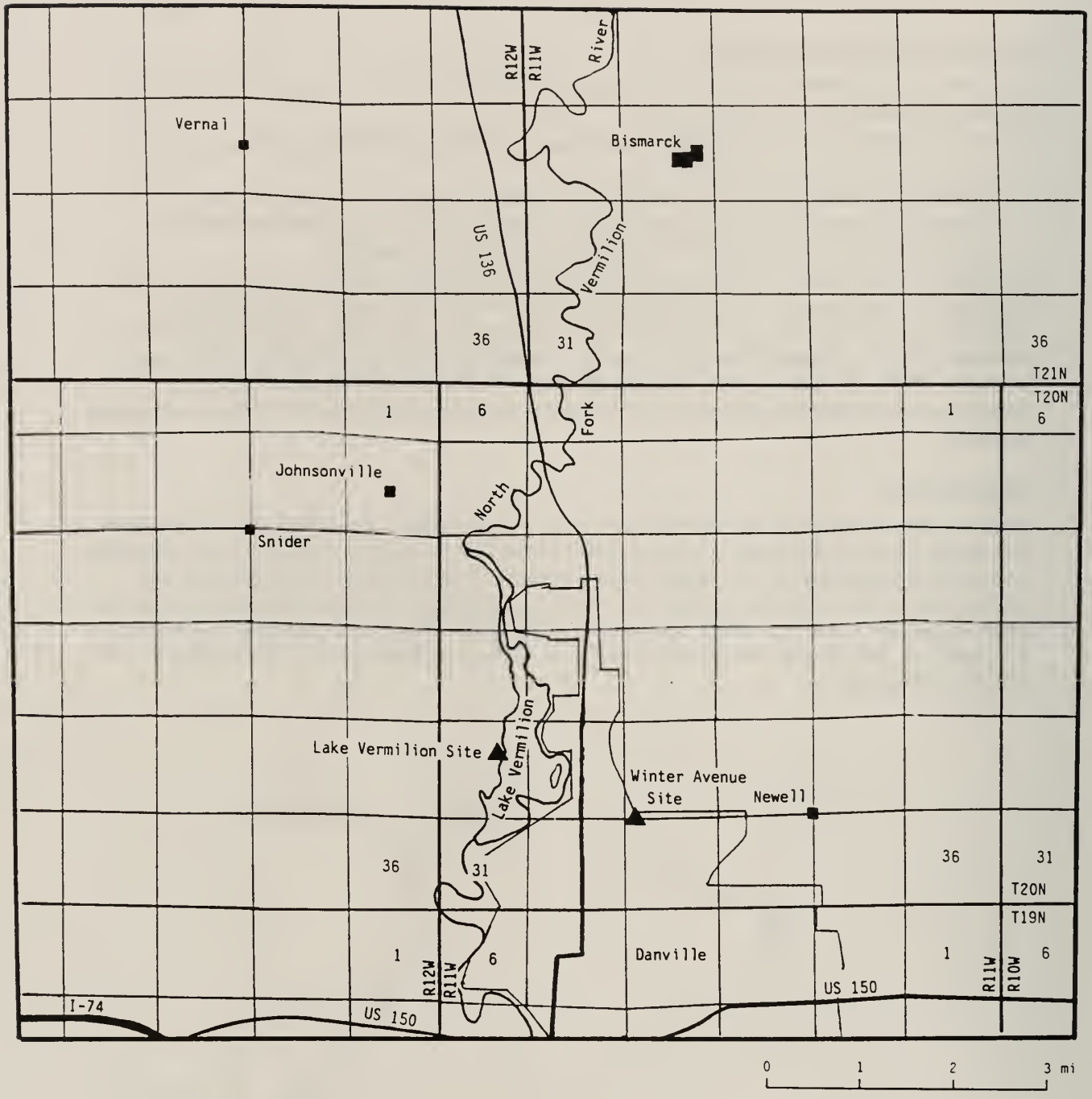


Figure 2 Location map for study area.

Background

Since the 1920s, Danville has relied on a reservoir (Lake Vermilion) on the North Fork Vermilion River to supply its water needs. The city began investigating ways of increasing its water supply when projected water demand exceeded the capacity of Lake Vermilion. The first alternative was to construct a reservoir on the Middle Fork Vermilion River. When plans for this project were canceled, the feasibility of augmenting the water supply from either surface water or groundwater sources was investigated by Singh (1978). He looked at two options for using surface water sources:

1. increase the storage capacity of Lake Vermilion,
2. pump water via pipeline from the Vermilion River to the water treatment plant.

Singh also considered three possibilities for using groundwater sources:

1. drill wells along the Wabash River northwest of Covington, Indiana, and pump the water to Danville,
2. drill wells within Danville,
3. develop a supply from the Mahomet Valley Aquifer in northern Vermilion County.

As a follow-up to Singh's study (1978), Kempton et al. (1981) investigated the groundwater resources of northern Vermilion County.

The option chosen for enlarging Danville's water supply was to increase the capacity of Lake Vermilion by raising the height of the dam by 5 feet. This did not, however, solve another problem with Lake Vermilion water, which has nitrate concentrations that sometimes exceed the standard set by the U.S. Environmental Protection Agency (USEPA) for drinking water. A better alternative for increasing Danville's water supply appears to be groundwater, which is not as vulnerable as surface water to drought, and generally has a very low nitrate content.

During the summer of 1987, drought caused both a water shortage and elevated nitrate concentrations in Danville's water supply. The groundwater resources in the Danville area were further studied by the Illinois State Geological Survey (ISGS), the Illinois State Water Survey (ISWS), and the water company. The study, which was based on an ISGS report (Vaiden 1987), included

- evaluation of old well fields on properties owned by the water company,
- seismic and resistivity surveys near Lake Vermilion,
- a test drilling program to define and evaluate the sand and gravel aquifer at the Winter Avenue and Lake Vermilion sites (fig. 2).

Shortly after this work was completed, the drought ended and the water-shortage problem was temporarily solved.

Reduced rainfall during the summer and fall of 1991 caused an extremely low level in Lake Vermilion and left Danville with a 60- to 90-day water supply. In October 1991, ISGS and ISWS staff met with water company officials and their drilling contractor (Layne-Western of Aurora, Illinois) to review the availability of groundwater in the vicinity of Danville, assess possible options for managing the water-supply emergency, and recommend a solution based on what was known about water resources of the area. Actions taken in the fall of 1991 included drilling a well on the west side of Lake Vermilion to pump water directly into the lake (the Lake Vermilion site), installing a test well about 2,000 feet north-northwest of the Lake Vermilion site, and drilling a test hole about 13,000 feet north and about 2,000 feet south of the Lake Vermilion site to help define the extent of the aquifer (fig. 2).

Significant rainfall across east-central Illinois during the late fall of 1991 caused the level of Lake Vermilion to rise, easing Danville's water shortage. The ISGS and ISWS agreed to review the data from the 1991 test holes and aquifer testing; compile, analyze, and report all of the data collected during the recent studies; update the aquifer maps; and make recommendations for groundwater resource exploration and development over the next 5 years.

Source and Availability of Groundwater

An aquifer is a body of saturated earth materials yielding a volume of groundwater to a well or spring at a rate sufficient for its intended purpose. Water will flow through nearly all geologic materials, but the rate of flow varies with the type of material. Water moves more rapidly through sand and gravel than it does through silt and clay. The amount of groundwater available from an aquifer depends upon how easily the water flows through the aquifer, how thick and extensive the body of earth materials is, how much water flows into and out of the aquifer, and how much is available from storage in the aquifer.

Certain hydraulic properties (transmissivity and storativity), which control the flow of groundwater through an aquifer, are used to describe its water-yielding and storage capacity. Transmissivity and storativity also determine how the aquifer and water wells drilled into it will respond to pumping. These properties can be calculated from an aquifer test or estimated from the drill logs and geological samples from water wells and other test borings.

Precipitation and surface water provide most of the groundwater recharge to aquifers. Although most precipitation runs off to streams or returns to the atmosphere by evapotranspiration, some of it seeps into the ground and moves downward until it reaches an aquifer. Leakage of water from streams and lakes (induced infiltration) contributes to groundwater recharge. Groundwater discharge from aquifers enters water wells, the surface water drainage system (baseflow), and the atmosphere by evapotranspiration.

Groundwater discharge generally balances groundwater recharge. Recharge from precipitation is typically greatest during the spring when water from rainfall and snow melt is abundant, and water losses through evapotranspiration are low. Recharge is generally lowest during the summer and early fall when evapotranspiration is high and most of the moisture in the soil is taken up by plants. Recharge can also be negligible during winter, if the ground is frozen.

Groundwater availability is controlled in part by the characteristics and layering of the various earth materials below land surface. Groundwater is thus readily available in some areas and difficult to obtain in others. Gathering information on the distribution and character of the various subsurface layers is essential for locating aquifers and managing groundwater resources for the benefit of the community.

Geologic Setting of the Danville Area

The bedrock formations in the Danville area (fig. 3) consist of sandstone, limestone, dolomite, shale, and coal. This succession of sedimentary rocks, which is several thousand feet thick, was warped and tilted over many millions of years by the formation of the Illinois Basin, centered in southeastern Illinois.

The older, deeper rocks in the Danville region are mainly limestone, dolomite, and sandstone. The younger rocks, which are at or within a few hundred feet of land surface, are mostly shale interbedded with coal, sandstone, and a few relatively thin layers of limestone. A long period of uplift occurred after deposition of the bedrock. Weathering of the uplifted bedrock produced the erosional topography on the bedrock surface of the Danville region. This surface includes a major river valley, the Mahomet Bedrock Valley, and its tributary valleys, such as the Danville Bedrock Valley (fig. 1).

Multiple advances and retreats of ice sheets characteristic of continental glaciers began to occur about 2 million years ago in the region that is now Illinois. The earliest of these ice sheets (fig. 4) altered the bedrock surface, modifying its shape by glacial scour and meltwater erosion, and in some places, creating new channels on the old surface. Underlying Danville and much of Lake Vermilion is the Danville Bedrock Valley (fig. 5), a tributary to the Mahomet Bedrock Valley (Kempton et al. 1991) located in northern Vermilion County (fig. 1). The rather narrow Danville Bedrock Valley generally trends northwest to southeast across the study area. The valley splits at the north end of Lake Vermilion (fig. 5); one branch trends north toward Bismarck, and the other trends west toward Snider.

As each ice sheet melted, it left behind a layer of debris commonly referred to as *glacial drift*, which consists of several types of deposits:

- *till*, a mixture of clay, silt, sand, and gravel to boulders deposited directly by the melting glacier;
- *outwash*, sand and gravel deposited by meltwater flowing from the glacier;
- *lacustrine sediments*, silt and clay deposited in lakes.

More than 300 feet of glacial drift covers the bedrock surface in the Danville study area (fig. 6). These deposits can be identified and mapped from the drill logs and geological samples from

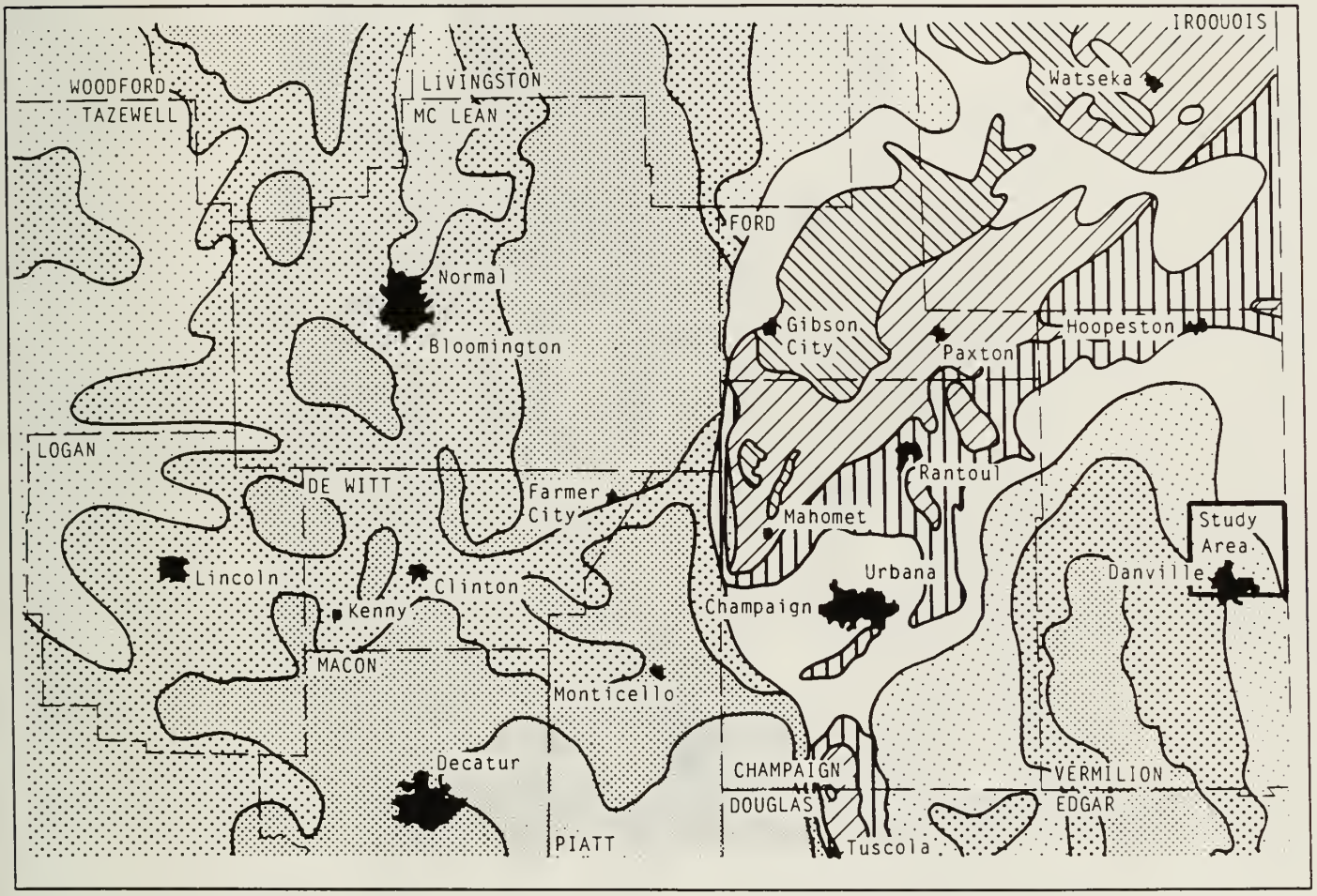


Figure 3 Bedrock geology of east-central Illinois (modified from Willman and others 1967).

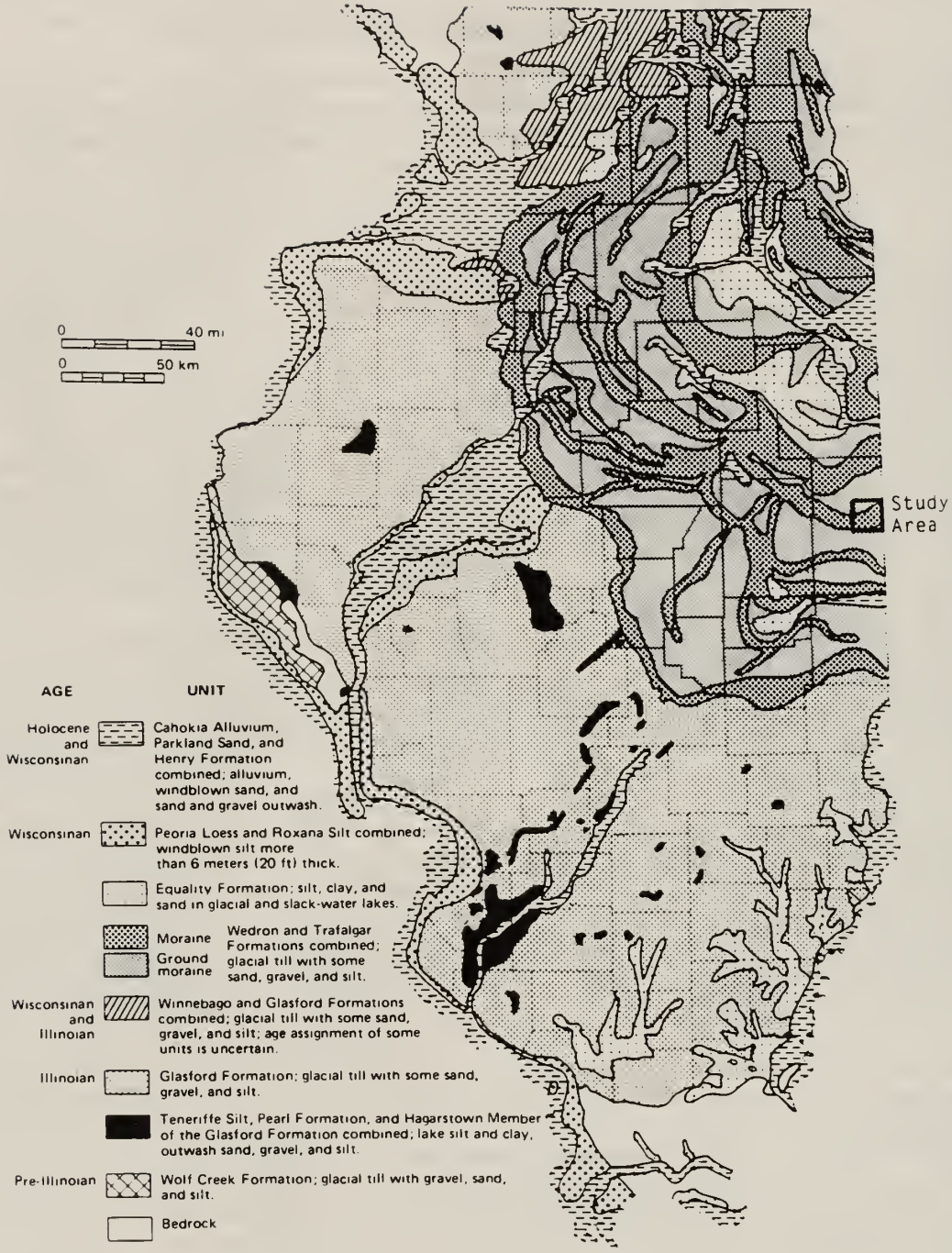
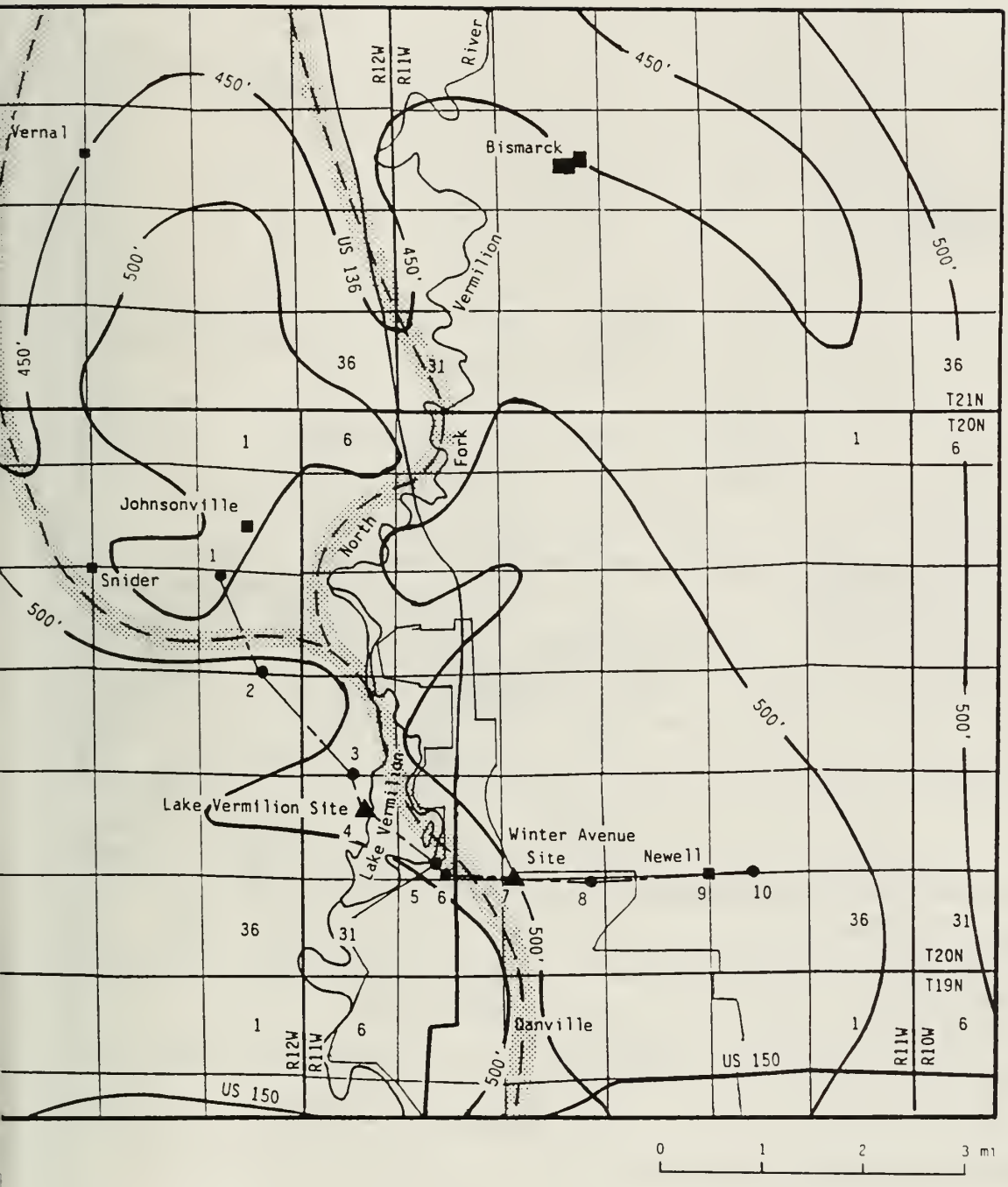


Figure 4 Glacial map of Illinois (Lineback 1981).



Map of the study area showing the bedrock surface topography and the line of the cross section Shading indicates the thalweg of the Danville Bedrock Valley.

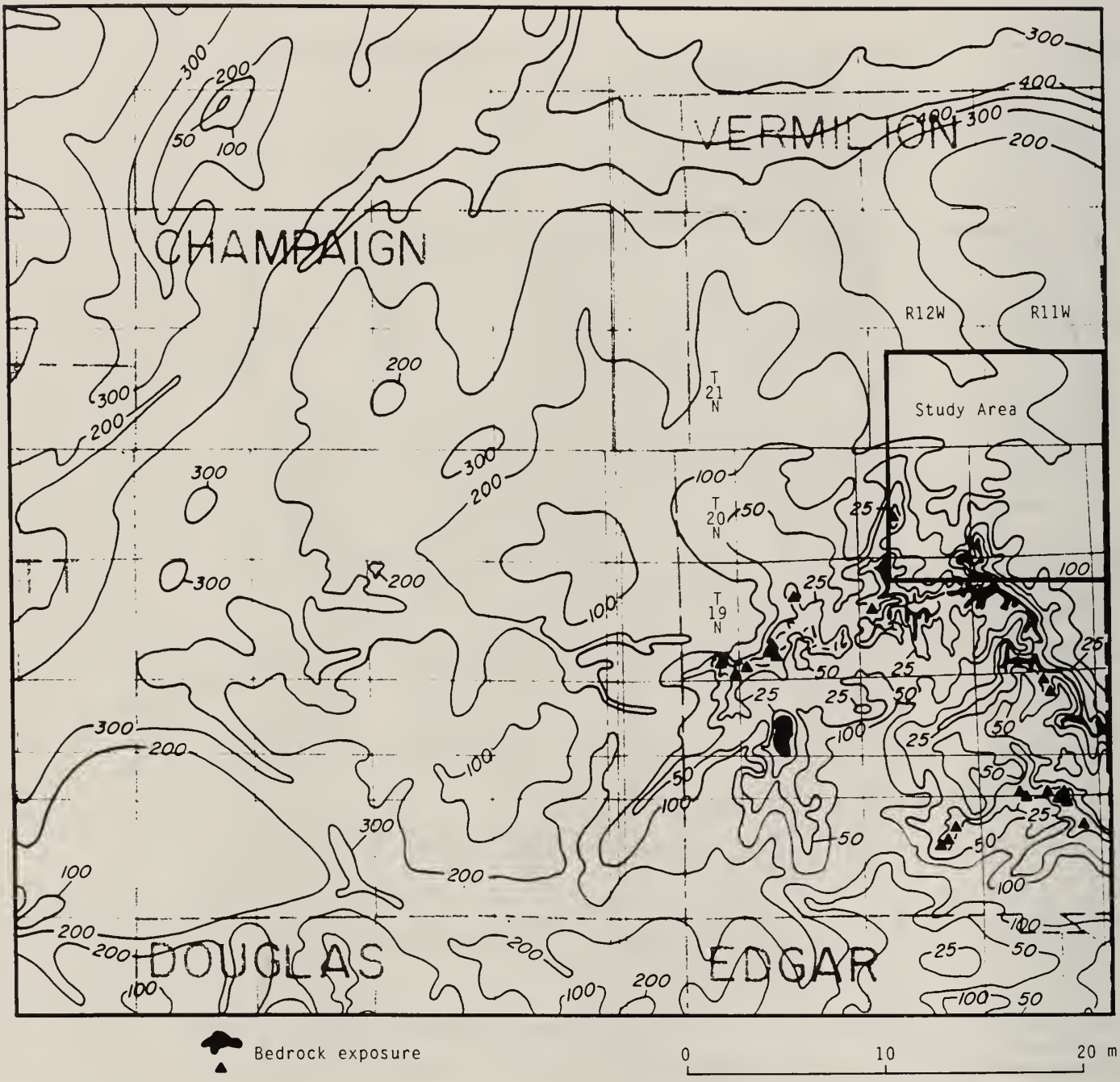


Figure 6 Drift thickness (from Piskin and Bergstrom 1975).

water wells and other test borings, as well as from exposures in stream banks, roadcuts, and strip mines. Figure 7 shows the general sequence of glacial deposits, including till, outwash sand and gravel, and other related deposits in the Danville area. Three formations in the glacial drift have been identified by ISGS and other researchers in recent years. From oldest to youngest, these are the Banner, Glasford, and Wedron Formations (fig. 7). The less extensive sand and gravel of the Henry Formation occurs mainly along the larger valleys. Identification of individual till units (members), as shown in figure 7, aids in mapping the sand and gravel units.

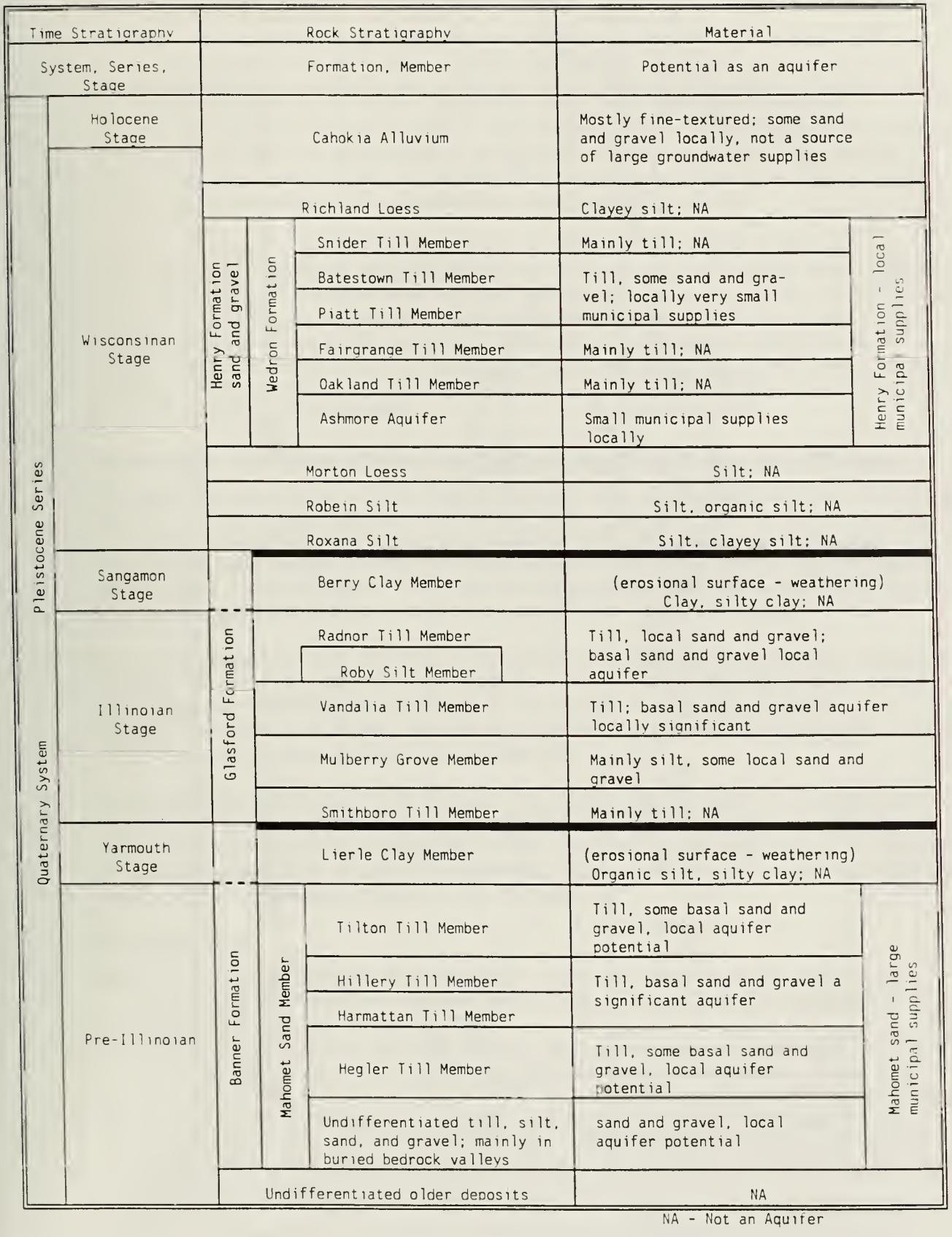


Figure 7 Sequence of glacial deposits and their potential as aquifers (from Kempton et al. 1982).

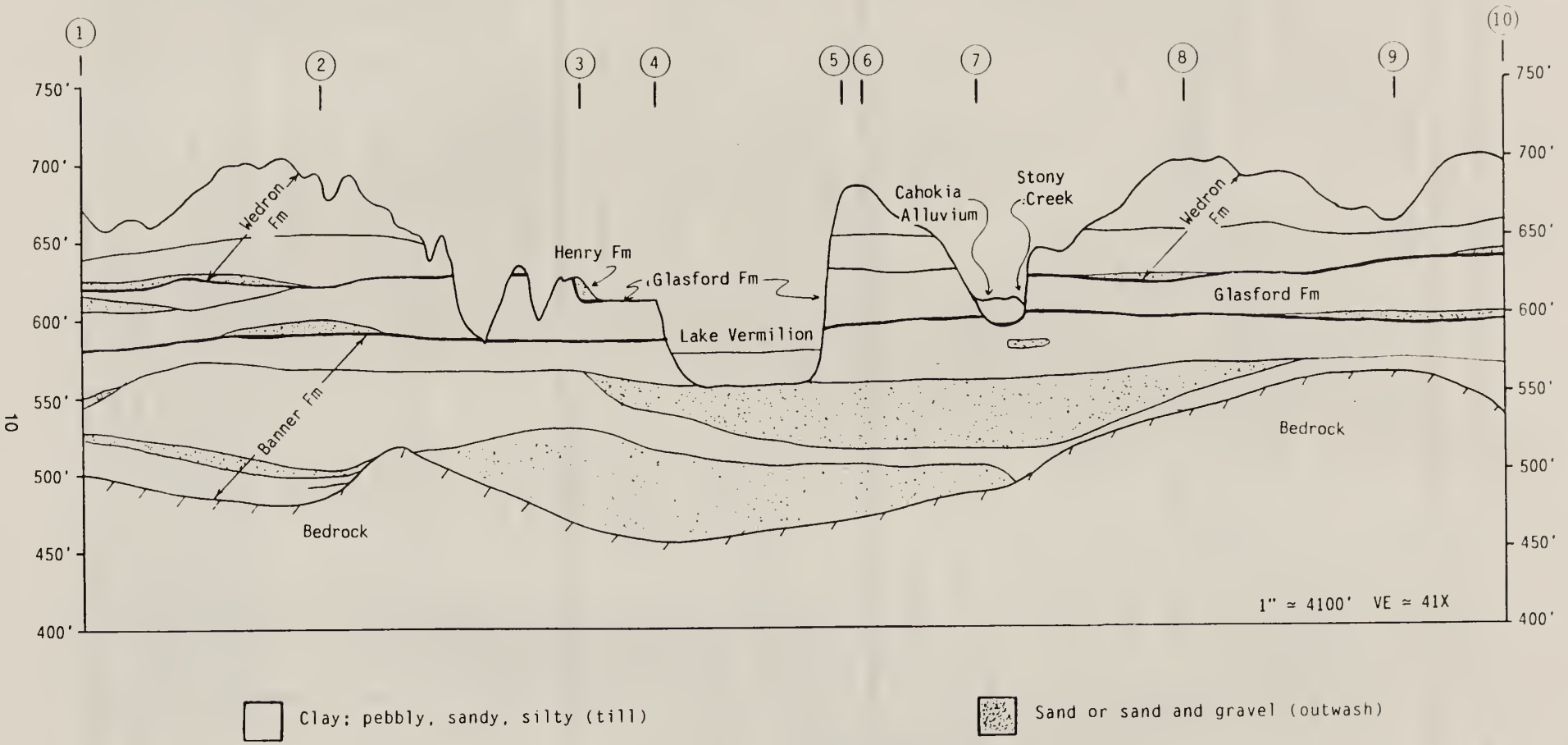


Figure 8 Schematic cross section of glacial deposits (from Kempton et al. in prep.). Wells and line of cross section are shown in figure 5.

Hydrogeologic Setting of the Danville Area

The older, deeper limestone, dolomite, and sandstone in the Danville area generally yield water. The younger rocks, at or within a few hundred feet of land surface, are mostly shale interbedded with coal, sandstone, and a few relatively thin layers of limestone. The shale does not readily yield water. Small yields may be obtained from the permeable sandstone or fractured limestone, but the aquifer yield is not sufficient to support high-capacity wells. Below depths of 200 to 400 feet, groundwater is generally too mineralized for most uses. Potable groundwater resources from bedrock aquifers in the Danville are limited to the shallow bedrock, but the yield is not sufficient for a supplemental water supply for Danville.

Deposits of outwash sand and gravel in the glacial drift form the principal aquifers in the Danville area. One aquifer is related to the Banner Formation (fig. 7). Outwash sand and gravel at the base of two till members of the formation apparently combine to form the Mahomet Sand to the north. This aquifer lies primarily within the Danville Bedrock Valley (figs. 5 and 8), which severely limits the extent of the aquifer and the amount of groundwater available to high-capacity wells. The limited extent and thickness of sand and gravel units in the Glasford and Wedron Formations make these aquifers suitable only for low-capacity wells, such as those used for domestic or farm supplies.

Hydrologic Appraisal of Sand and Gravel Aquifers in the Danville Area

The sand and gravel aquifers in the Danville Bedrock Valley within and immediately north of the Danville area can support very few high-capacity wells, as demonstrated by aquifer mapping and testing at the Winter Avenue and Lake Vermilion sites. The aquifer underlying Lake Vermilion receives enough recharge to sustain long term withdrawal of about 700,000 gallons per day (gpd). This is equivalent to a single well pumping about 500 gallons per minute (gpm), substantially less than the requirements for a supplemental supply for Danville.

Induced recharge from Lake Vermilion could somewhat increase the amount of groundwater available. However, the potential for an increase in the nitrate concentration of water pumped from the aquifer diminishes the advantage of this leakage. Because Lake Vermilion is the source of Danville's water supply, induced recharge from the lake may not significantly increase the total amount of water available to supply the city.

Drawdown from high-capacity wells finished in the sand and gravel aquifer underlying Lake Vermilion might adversely affect nearby water wells along the Danville Bedrock Valley. Long term interference caused by pumping 500 to 700 gpm from one well adjacent to Lake Vermilion is estimated to add 14 to 20 feet of drawdown at a distance of 200 feet from the well and 5 to 6 feet of additional drawdown 5,000 feet from the well.

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